

1. (a) (i) At equilibrium, length submerged = x_0

$$\Delta x_0 (1000)g = \Delta (0.20)(800)g$$

$$x_0 = 0.16 \text{ m}$$

1

(ii) Suppose the object is submerged for length $x < x_0$:

$$\text{Resultant force} = \Delta(0.20)(800)g - \Delta(x + x_0)(1000)g$$

$$= -\Delta x$$

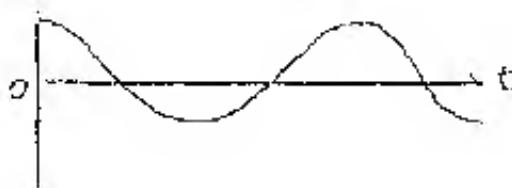
1

(another mark for -ve sign)

1

(iii)

$\propto F$



sine curve
 $t = 0, F$ at ωx
 (+ve or -ve)

1

1

(iv)

$$\frac{d^2x}{dt^2} = -x \quad \therefore T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{16}{1000}} \text{ s}$$

1

$$\approx 0.79 \text{ s or } 0.80 \text{ s}$$

1

(v)

$$\text{Max. amplitude} = 0.20 - 0.16 = 0.04 \text{ m}$$

1

Beyond this, the cylinder is completely submerged; restoring force ceases to be proportional to x .

1

(vi)

In a wide container, KE (water) can be neglected; PE(cylinder) + KE(cylinder) + PE(water) = constant.

1

(b) (i)

Damped SHM

energy transformed to internal energy of water and cylinder, temperature rises.

1

1

(ii)

System unstable : any deviation from vertical not subject to restoring torque.

1

1

Cylinder would fall over and end up floating on its side.

1

1

2. (a)

$$pV = nRT$$

$$(1.01 \times 10^5) \frac{m}{(1.43)} = 1(8.31)(273)$$

$$m = \frac{1(8.31)(273)(1.43)}{(1.01 \times 10^5)} = 0.0321 \text{ kg}$$

(b) (i)

$$\pi = a_1 + a_2$$

$$p^e = p_1 V_1 + p_2 V_2$$

$$(20 \times 10^5)(0.5) = (10^5)(5) + p_2(0.5)$$

$$p_2 = 5 \times 10^5 \div 0.5 = 10^5 \text{ Pa}$$

$$(ii) (20 \times 10^5)(0.5) = (10^5)V_1 + (10^5)(0.5)$$

$$V_1 = 9.5 \text{ m}^3$$

(iii) If very slow inflation
permits heat exchange with surroundings
∴ temperature constant

3. (a) The 2 beams of light travel different paths
 constructive interference for p.d. = $m\lambda$ and
 destructive interference for p.d. = $(m + 1/2)\lambda$

(b) Change in optical p.d. = $2t(\mu - 1)$
 $= m\lambda$

$$t = \frac{1 \times 480}{2 \times 0.45} \text{ nm}$$

$$= 3730 \text{ nm}$$

(c) (i) As M_2 is moved, path difference between the 2 beams
 is increased; a shift of fringes is observed.

(ii) $2d = m\lambda$
 $d = \frac{800}{2} \times 480 \text{ nm} = 0.192 \text{ mm}$

(d) Since the two wavelengths differ by 0.6 nm, the
 interference patterns from these wavelengths will not
 always overlap.

The interference pattern disappears when the dark fringes
 from one of the wavelengths fall on the bright fringes of
 the other.

The pattern reappears when the bright fringes from the
 two wavelengths coincide again.

4. (a)



straight line with
-ve slope
cuts t-axis at 50 s

1

(b) Theoretically, charge accumulated at uniform rate, V_C increases linearly; V_R drops linearly. }

1

V_R approaches a constant value means that the p.d. across the capacitor, and hence the charge stored in it, also becomes steady. }

1

At this stage, the current will not charge up the capacitor any further but will be all leaking away, i.e. an equilibrium state has been reached. }

1

(c) (i)



ordinary charging curve

1

achieves a constant value later

1

(ii) At equilibrium, $V_R = 2.4$ V
P.d. across capacitor = $(12 - 2.4)$ V
= 9.6 V

1

Hence, charge stored on capacitor

$$= (500 \times 10^{-6})(9.6)C$$

1

$$= 4.8 \times 10^{-3} C$$

1

(iii) Since p.d. across capacitor at equilibrium = 9.6 V and leakage current = $120 \mu A$.

$$\text{Leakage resistance} = \frac{9.6}{120 \times 10^{-6}} \Omega$$

1

$$= 80 \text{ k}\Omega$$

1

3. (a) (i) The result shows that the induced e.m.f. in the search coil is proportional to $1/r$.
 $\propto 1/r$ for a long, current carrying, straight wire. 1

(ii) When the distance of the search coil from the straight wire is comparable to the finite length of the wire,
 the induced e.m.f. is less than it should be for a infinitely long wire. Therefore, those data points lie above the fitted straight line. } 1

(b) (i) $B = \mu_0 I / 2\pi r \propto \mu_0 I_0 \sin(2\pi f t) / 2\pi r$ 1
 $\text{emf} = NA \frac{dB}{dt}$

$$= (\mu_0 N A I_0 f / r) \cos(2\pi f t) 1$$

$$V = 2\mu_0 N A I_0 f / r 1$$

(ii) slope of line = $1800 \text{ V}^{-1} \text{ m}^{-1}$ 1
 $= 1 / (2\mu_0 N A I_0 f)$ 1

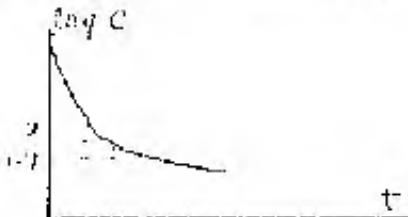
$$N = \frac{1}{2 \times 1.26 \times 10^{-6} \times 3.14 \times 10^{-4} \times 14.1 \times 50} \text{ turns} 1$$
 $\approx 1000 \text{ turns}$ 1

(c) His argument is wrong. 1

The earth's magnetic field is more or less a steady, low intensity field } 1
 which would not give rise to any measurable induced e.m.f. in the search coil. } 1

6. (a) After several days, the activity of iodine-133 has decreased to an insignificant level, leaving only the activity of iodine-131 to be shown up on the decay curve which when plotted on a log-scale, is a straight line.

(b)



$$\begin{aligned}
 N &= N_0 e^{-\lambda t} \\
 \Rightarrow \text{slope of line} &= -\frac{\ln 2}{T} \log_{10} e \\
 &= -0.375 \text{ day}^{-1} \\
 \frac{T_1}{2} &\approx \frac{\ln 2 \times \log_{10} e}{0.375} \\
 &= 6 \text{ days}
 \end{aligned}
 \quad \left. \begin{aligned}
 &\text{extrapolate the straight} \\
 &\text{portion to find the initial} \\
 &\text{activity of I-131 to be} \\
 &10^1 = 100 \text{ cpm.} \\
 &\text{find time corresponding to} \\
 &0 = \frac{1}{2} \times 100 \text{ or } \log N = 1.7. \\
 &\text{half-life of I-131 is 8 days.}
 \end{aligned} \right\} 1$$

$$\begin{aligned}
 (c) (i) \quad \text{initial count-rate for I-131, } C_1 &= 10^2 \text{ cpm} \\
 \text{initial count-rate for I-133, } C_2 &= 10^{2.9} = 10^1 \text{ cpm} \\
 &= 694 \approx 700 \text{ cpm}
 \end{aligned}
 \quad \left. \begin{aligned}
 &1 \\
 &1
 \end{aligned} \right\} 1$$

$$(ii) \quad \text{count-rate} = dN/dt = \lambda N$$

$$\text{knows } C_1/C_2 = \lambda_1 N_1 / \lambda_2 N_2 \quad 1$$

$$\text{knows } \lambda_1/\lambda_2 = T_2/T_1 \quad 1$$

$$\text{knows } N_1/N_2 = 131 N_1/133 N_2 \quad 1$$

$$N_1/N_2 = \frac{131}{133} \times \frac{N_1}{N_2}$$

$$= \frac{131}{133} \times \frac{C_1}{C_2} \times \frac{2}{1}$$

$$= \frac{131}{133} \times \frac{C_1}{C_2} \times \frac{T_1}{T_2}$$

$$= \frac{131}{133} \times \frac{100}{700} \times \frac{8 \times 24}{20.8}$$

$$= 1.30$$

1